War Department Specification

STREET LIGHTING DURING BLACKOUTS

U. S. OFFICE OF CIVILIAN DEFENSE

Washington, D. C.

The following other subjects are covered in specifications being prepared by the War Department:

Blackout of buildings.
Blackout requirements for highway movement.
Blackout flashlights, lanterns, and flares.
Traffic control during blackouts.
Blackout for railroads.
Luminescent materials.

The other specifications will be published as soon as completed.

The purpose of these specifications is threefold:

To provide military and civilian authorities with authentic information on blackout equipment and its application.
To assist commanders in insuring the military security of installations under their jurisdiction.
To conserve the use of strategic and critical materials.

Prepared under the direction of the Chief of Engineers, United States Army, by the Engineer Board, with suggestions of the National Technological Civil Protection Committee, the National Defense Research Committee, and the National Bureau of Standards.

FOREWORD

The standards specified herein may be imposed by military authority during specified periods and in specified areas. Independent of such action these standards afford guides to civilian authorities as to measures that can be taken by them to conform their conduct with what may eventually be prescribed.

Due to the scarcity of certain critical materials which will be involved in the manufacture of the equipment called for in these specifications, it is probable that only the most exposed communities in the continental United States will be able to procure the equipment. For this reason these specifications are being given only a limited distribution at this time.

TABLE OF CONTENTS

STREET LIGHTING DURING BLACKOUTS

1. Scope.—Standards of blackout street lighting set forth herein are applicable to docks, loading platforms, yards, grounds, open sheds, parks, and other exterior facilities, as well as to streets, roads, underpasses, sidewalks, and other thoroughfares, within those areas and during those periods specified by proper military authority. Standards of blackout lighting permitted for traffic signs and signals, vehicles, flashlights, advertising signs, show windows, or other illumination on or near streets are included in one of the following War Department specifications:

a. Blackout Requirements for Highway Movement.

b. Blackout of Buildings.

c. Traffic Control During Blackouts.

d. Blackout Flashlights, Lanterns, and Flares.

2. General Instructions.[1]—*a.* This specification has been prepared on the premise that normal street lighting will prevail except when and where blackouts are ordered by proper military authority. Any curtailment of present street illumination at other times is not recommended. Reduction in voltage, lamp size, or number of street lamps results in added traffic hazard without any significant decrease in ease of detection and identification from the air.

b. Within areas designated by proper military authority local officials responsible for street lighting should make the following arrangements in preparation for blackouts:

(1) Provide switching facilities and assign personnel to insure that the present street lighting system will be turned off quickly—in not more than five minutes—after the official blackout signal has been given.

(2) In consultation with responsible local military authority, make a survey to determine locations where an auxiliary blackout lighting system may be desirable in the event blackouts become frequent or of long duration. In general, such locations will be those where substantial pedestrian movement is expected during blackouts—business and office districts, shopping centers, roads and walks leading to war plants, important crosswalks on heavily traveled thoroughfares, etc. This survey should provide the following information:

(*a*) Listing of locations in order of their importance.

(*b*) Detailed plan for placing and mounting each blackout lighting unit.

(c) Most convenient source of power for each unit and amount of new wiring and other equipment needed.

(*d*) Inventory of wire (iron wire is satisfactory for this purpose) brackets, and other necessary supplies which are already on hand.

(*e*) Statement of additional equipment and material required.

(3) Whenever blackouts become frequent or of long duration, install blackout lighting in accordance with this specification to the extent justified by local conditions.

3. Purpose of Blackout Street Lighting.—Complete elimination of all artificial light constitutes the most effective possible blackout. However, a total blackout seriously handicaps the activities of personnel engaged in air raid duties—wardens, doctors, nurses, firemen, police, and military personnel—at the very time when it is of vital importance that they be able to move about and perform their services efficiently. It is the purpose of blackout street lighting to provide the greatest possible illumination for ground activities commensurate with reasonable protection from aerial observation.

4. Limitations of Blackout Street Lighting.—Blackout street lighting, although a very valuable aid to vehicular and pedestrian movement during blackouts, obviously provides such low visibility that anything approaching normal movement is impossible. Resort to blackout street illumination, therefore, except when a raid is imminent, results in serious losses. One of these losses is the inevitable increase in traffic fatalities, personal injuries, and property destruction. There

[1] *Instructions for areas equipped with gas lighting are covered in Appendix C.*

is also the slowing down of war activities caused by sharply reduced speed of transportation of essential personnel, military equipment, and critical materials. Another loss is depressed civilian morale and lowered efficiency. Except during periods when a raid is imminent, efficient functioning of the whole war effort requires that normal street lighting be maintained in common with other means for safeguarding and facilitating traffic.

5. Control of Blackout Street Lighting Circuits.—Satisfactory operation of blackout street lighting may be obtained by either of 2 methods. Preferably since wattage is low, lamps may be connected in multiple to secondary distribution circuits, without switching provision, and burned continuously. This method is likely to result in lowest over-all cost, besides conserving labor and materials and insuring that the blackout lighting will be on whenever needed. The alternative method is to provide switching facilities and assign personnel to turn the lighting on quickly—in not more than 5 minutes after the official blackout signal is given.

6. Allowable Illumination.[2]—*a.* The illumination over the street on a horizontal surface at street level shall average approximately 0.0003 foot-candles, and shall nowhere exceed 0.0006 foot-candles. This amount of illumination is approximately double that provided by starlight on a clear, moonless night.

b. The light shall be "white" as produced by a tungsten filament lamp[3] operating at approximately its rated voltage. Extensive studies have shown that "blue" light is not suitable for blackout street illumination, because (1) it is most easily detected from the air by dark-adapted aerial observers, (2) it provides hazy and indistinct visibility for ground activities, and (3) it becomes useful on the ground only after a relatively long period of dark adaptation of vision.

7. Light Distribution.[3]—*a.* A special design of blackout street lighting luminaire is required to meet this specification. The candlepower distribution curve of the luminaire when equipped with the standard blackout street lighting lamp (see par. 8) shall, in all vertical planes, lie wholly inside the limiting curve marked A in Figures 1, 2, or 3 according to the appropriate nominal mounting height (see par. 10). The distribution curve in any vertical plane making an angle of less than 45° with the vertical plane parallel to the street axis shall lie outside the corresponding limiting curve B. In other vertical planes the candlepower at any angle shall be not less than onehalf of the candlepower shown on curve B at the same angle.

b. All photometric tests to determine compliance with the specification shall be conducted in a nationally recognized testing laboratory. No street performance tests are to be made because of the difficulties and inaccuracies of measuring such low values.

8. Incandescent Lamps.[3]—Incandescent lamps employed in these luminaires shall be 10-watt inside frosted lamps which have been especially designed to meet the requirements of this service (long life and resistance to shock) and shall be marked: "FOR USE IN BLACKOUT LUMINAIRES." If these standard blackout street lighting lamps should not be at hand when required for emergency replacements, the 10-watt inside-frosted general service lamp may be used. However such substitute use of the general service lamp is warranted only as a temporary expedient because its construction is not sufficiently rugged and its life is too short for this service. Lamps must be properly used in approved luminaires. They must not be used bare or in unapproved luminaires.

9. Maintenance of Luminaires.—*a.* Blackout luminaires should be inspected at least once a week to verify that the lamp and the lighting unit are in proper operating condition. They should be cleaned at least twice a year, and preferably four to six times a year in smoky or dusty locations.

b. Where blackout street lighting is operated continuously without switching provision, periodic replacement of all lamps should be made at intervals of four months. Standard blackout street lighting lamps are of such design that there will

[2] *A glossary of lighting terms is given in appendix A.*

[3] *For conversion of gas lamps to meet blackout street lighting requirements see appendix C.*

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b. Where blackout street lighting is operated continuously without switching provision, periodic replacement of all lamps should be made at intervals of four months. Standard blackout street lighting lamps are of such design that there will

[2] *A glossary of lighting terms is given in appendix A.*

[3] *For conversion of gas lamps to meet blackout street lighting requirements see appendix C.*

normally be but few burnouts between periodic replacements.

c. Where blackout street lighting is switched on only during blackouts and during weekly inspections, all lamps preferably should be replaced at intervals of four to eight months. Such periodic replacement is recommended as a means of minimizing lamp failures during an emergency, even though the lamps have actually burned only a few hours. The reason for this precaution is that low-wattage lamp filaments are less able to withstand vibration and shock when cold than when burning, and after 4 to 8 months in this service their mechanical strength is likely to be seriously impaired.

10. Mounting Height and Spacing.—The light distributions prescribed in paragraph 7 are associated with nominal mounting heights of 10, 15, and 20 feet as marked on the luminaires (see par. 15). Luminaires having these distributions may be mounted at heights as shown below, with the requirement that the spacing of the luminaires measured along a line joining them in plan, must be more than 100 feet and preferably not less than 150 feet. Single luminaires are applicable at isolated locations.

Nominal mounting height as marked on the luminaire	Range of mounting heights for which the luminaire may be used	Limits of distribution
Feet	*Feet*	
10	9–14	Fig. 1.
15	15–19	Fig. 2.
20	([1])	Fig. 3.

[1] 20 feet and upwards.

11. Mounting and Erection.—*a.* It is not intended that new poles be erected, except under unusual circumstances, to support blackout street lighting luminaires. For mounting the luminaires, those existing wood or metal poles should be selected which afford reasonably uniform spacing with maximum permissible illumination on intersections, crosswalks, and other points of hazard.

b. Luminaires should be mounted rigidly and, if they provide an asymmetric (nonsymmetrical) light distribution, correctly oriented.

c. Where luminaires are closely adjacent to light-colored surfaces or expanses of water, dull black side screens should be provided to prevent direct light falling upon such surfaces. An alternative is to paint such adjacent light colored surfaces a dull black.

12. Construction.[4]—*a.* The construction of luminaires complying with this specification shall be such that:

(1) Those parts which control the optical properties are not liable to variation or derangement in maintenance or use.

(2) The materials and construction are rugged and are not subject to such deterioration in service as to be likely to bring the photometric performance outside the limits laid down in paragraphs 6 and 7.

(3) Luminaires are as small as practicable, preferably with a maximum overall dimension of not more than 8 to 10 inches.

(4) Provision is made for ready maintenance and lamp replacement.

b. Sketches of two optical designs which might be employed for blackout street lighting luminaires are shown and described in Figures 4 and 5. Other optical designs may also be employed.

13. Design Approval.—Approval of luminaire designs, including both optical performance and mechanical features, shall be based on reports submitted to the War Department by testing laboratories. A list of the laboratories which have been accredited as of this date is attached hereto, but does not constitute a part of this specification.

14. Photometric Testing.—*a.* The test luminaire shall be assembled in accordance with manufacturer's instructions, with a standard blackout street lighting lamp as the test lamp. Such instructions for assembly must accompany each luminaire.

b. The candlepower distribution shall be determined by a photometer, the receiving surface of

[4] *See appendix C for construction of blackout attachments for gas luminaires.*

which is not less than 2 feet from the light source. (See appendix B.) The test lamp should be operated at or near rated lumen output; if operated at other than rated lumens, the candlepower values shall be rated accordingly.

c. The candlepower distribution thus obtained, when plotted as a polar curve, shall comply with paragraph 7. If the distribution curve falls outside these limits at any point, the luminaire shall be deemed not to comply with this specification.

15. Marking.—Approval of luminaire design shall be indicated by the marking, "STREET BLACKOUT — WAR DEPT. STANDARD." Units shall also display code numbers to be assigned by the War Department at time of approval which shall be placed directly beneath or after the word "Standard." In addition, luminaires shall be marked with the appropriate mounting height (or mounting heights, if changes of internal masks may be employed to vary the candlepower distribution). If designed to provide an asymmetric distribution, they shall be marked to indicate correct orientation.

16. Construction of the Limiting Curves.—The limiting candlepower distribution curves, (a) and (b) in Figs. 1, 2, and 3, are based on the values in Tables 1, 2, and 3, respectively.

FIGURE 1.—Mounting height 9 to 14 feet.

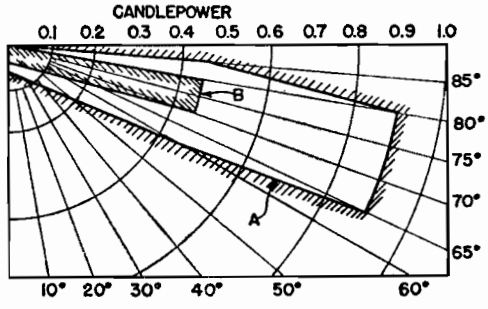

Table 1.—*Candlepowers for nominal 10-foot mounting height (fig. 1)*

Angle	Curve A	Curve B
°		
0	0.06	0.03
60	.45	.13
65	.90	.22
70	.90	.45
80	.90	.45
85	.45	.00
90	.00	.00

FIGURE 2.—Mounting height 15 to 19 feet.

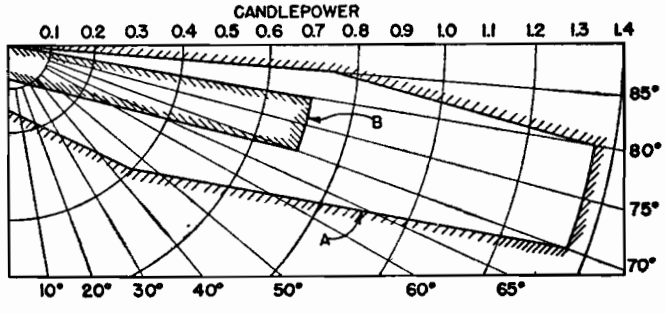

Table 2.—*Candlepowers for nominal 15-foot mounting height (fig. 2)*

Angle	Curve A	Curve B
°		
0	0.14	0.07
45	.40	.15
70	1.35	.70
80	1.35	.70
85	.75	.00
90	.00	.00

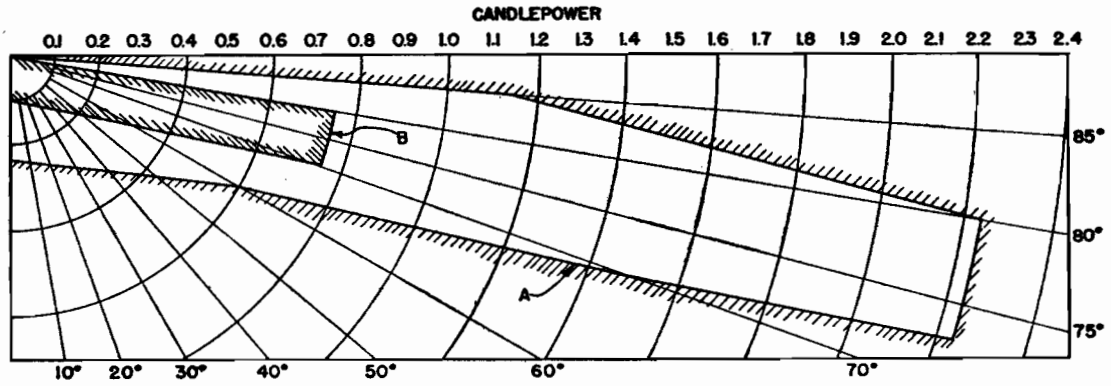

FIGURE 3.—Mounting height 20 feet and upward.

Limits of polar curves of candlepower distribution for blackout street lighting luminaires of the mounting heights indicated.

Table 3.—*Candlepowers for nominal 20-foot mounting height (fig. 3)*

Angle	Curve A	Curve B
°		
0	0.25	0.10
60	.60	.35
70	1.50	.75
73	2.25	.75
80	2.25	.75
85	1.15	.00
90	.00	.00

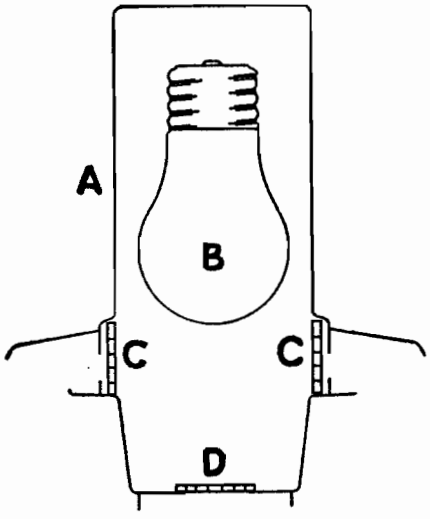

FIGURE 4.

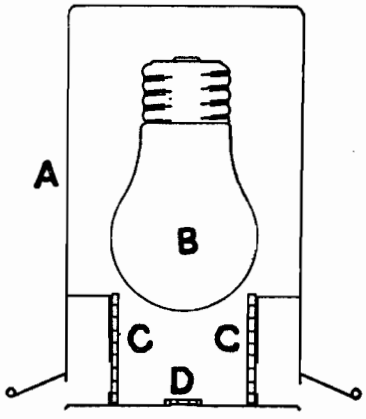

FIGURE 5.

Examples of Optical Designs of Blackout Luminaires.

These sketches are based upon two of the more widely used British designs of blackout luminaires. The materials used are light in weight but firmly assembled. The maximum over-all dimension of 8 to 10 inches—with proper provision for lamp replacement and maintenance. In these optical designs the lamp housing, A, is painted white inside and dull black on the outside. The dimensions and position of the inside-frosted lamp, B, may be varied within reasonable tolerances without altering appreciably the light distribution or output of the luminaire. The cylinder, C, may be of opal glass, or it may be perforated metal in which gradations in the perforations produce an asymmetric distribution. Changes in the glass or perforated metal may be made as a means of varying the light distributions to meet the requirements in figures 1, 2, and 3, with no other changes in the unit. The plate D may be opal glass or perforated metal. It will be noted that there is a minimum of exposed glass parts in these designs.

APPENDIX A

GLOSSARY OF LIGHTING TERMS

Candle.—The candle is the unit of light intensity. The unit used in the United States is a specified fraction of the average horizontal candlepower of a group of 45 carbon-filament lamps preserved at the National Bureau of Standards, when the lamps are operated at specified voltages.

Candlepower.—Candlepower is light intensity expressed in candles.

Footcandle.—The footcandle is the unit of illumination when the foot is taken as the unit of length. It is the illumination on a surface one square foot in area over which one lumen is uniformly distributed.

Footlambert.—The footlambert is a unit of brightness equal to the average brightness of any surface emitting or reflecting one lumen per square foot.

Lumen.—The lumen is the unit of light quantity. A uniform point source of one candle emits 12.56 lumens.

Luminaire.—A luminaire is a complete lighting unit consisting of a light source, together with its direct appurtenances, such as globe, reflector, refractor, housing, and such support as is integral with the housing. In street lighting units the pole, post, or bracket is not considered a part of the luminaire.

APPENDIX B

NOTES ON THE DESIGN AND TESTING OF STREET LIGHTING LUMINAIRES TO COMPLY WITH THE SPECIFICATION

1. *Photometry.*—*a.* Determination of the light distribution of street lighting luminaires to comply with the specification involves measurement of 0.03 to 2.25 candles. This is a range far below that which is ordinarily involved, and certain precautions are therefore necessary.

b. The low candlepowers involved suggest the use of a short testing distance between the luminaire and the photometer. The minimum of 2 feet mentioned in paragraph 14 may, in many cases, not be satisfactory and should be used only with caution. It is desirable to use greater testing distances on account of the errors introduced by applying the inverse square law at short distances, the difficulty of screening, and the difficulty of defining properly the effective light-center of the fitting. At short distances, a change in the position of the light-center may result in a significant change in candlepower distribution. Testing distances should preferably be not less than 10 times the greatest dimension of the effective source, or of the receiving surface of the photometer, whichever is the greater. The receiving surface should be as small as possible, preferably not larger than the effective light-source. Where the surface is greater in one dimension than in another, its smaller dimension should lie in the plane in which the candlepower distribution curve is taken.

c. The photometer used must be capable of operating at very low illumination levels. At 0.03 candles the illumination on a receiving surface 4 feet from the luminaire is only 0.0019 footcandles. Commercial photoelectric photometers designed for the more usual levels of illumination are not as a rule sufficiently sensitive, though laboratory photoelectric photometers of adequate sensitivity

are quite satisfactory. Visual photometers should have an apparent field of the order of 5° to 10°; a 2° field is extremely difficult to see at these levels. If the instrument has an artificial pupil, this should be as large as possible and preferably not less than 5 millimeters in diameter. Greater sensitivity can be obtained at low levels if both eyes can be used normally without the restriction of an eyepiece. The photometer should be calibrated with a level of illumination on the receiving surface comparable with that to be measured.

d. The use of a large photometer field at low brightness makes it particularly important to avoid color differences between the comparison, test, and standard lamps. Quite large color differences cannot be seen as such at these low levels, but they make a serious error in the measured values owing to the Purkinje effect. Natural filters of high density should be used with caution, as they are likely to introduce differences of energy distribution. For visual photometry the observer should have a period of at least 15 to 20 minutes of dark adaptation before commencing to take measurements, and he should not have to read illuminated scales, etc., during the course of the measurements.

e. The correct screening of the photometer from extraneous stray light is of particular importance at low illumination levels, where stray light, which would normally be imperceptible, may amount to as much as the light which is being measured. Reliance should not be placed upon black walls, but the photometer should be positively screened (care being taken to avoid reflection from the screen edges) and a large black screen placed at some distance behind the test luminaire. The side of the screens visible from the photometer (except of course the back screen) should be unable to receive light from the luminaire, and the photometer receiving surface should be invisible from any point in the room except within a few inches of the luminaire under test.

f. Candlepower determinations should be made at intervals of not more than 10° between 0° and 60° from the downward vertical, and thereafter at intervals of not more than 5°, such intervals being as small as may be necessary to determine the true shape of the curve. The planes of the maximum and the minimum candlepowers can probably be found by inspection, hence it would not normally be necessary to make determinations in many vertical planes. A distribution curve which is a mean of curves in several planes should not be used to check compliance with the specification; the requirements of paragraph 7 apply to distribution curves in any plane.

2. *Optical Stability.*—A preferred luminaire design is one in which a minimum of change in light distribution results from variation in the position of the filament brought about by manufacturing tolerances permitted for the lamp and the accessories used, or by normal variations in assembly or maintenance. An unsatisfactory luminaire design is one in which the light distribution depends critically upon the position of some part, the accurate location of which cannot be assured. Reliance should not be placed on a quality of black paint or similar materials which do not provide sufficient permanence.

3. *Mechanical Stability.*—*a.* The necessary mechanical stability of the luminaire is associated with the sensitiveness of its light distribution to variations in construction, assembly, or maintenance; and this should be taken into account in the design. For example, luminaires should be so designed that their performance is insensitive to such mechanical changes as the fitting used might undergo in service. Finishes upon which the photometric performance depends should be reasonably permanent and unlikely to deteriorate under weather, cleaning, or heat. The method of manufacture and assembly should be capable of maintaining, with sufficient accuracy, any dimensions to which the light distribution is sensitive; for example, an aperture should not be formed between two parts not rigidly connected. The construction should be sufficiently rigid, not only to maintain the light distribution and to hold parts in place, but to withstand the severe vibration which may be experienced in service.

b. Compliance with paragraph 12 does not imply an elaborate or expensive luminaire, but only seeks that degree of stability in use under practical conditions necessary to maintain the light distribution and to prevent the emission of undesirable light.

APPENDIX C

CONVERSION OF GAS STREET LAMPS TO MEET BLACKOUT STREET LIGHTING REQUIREMENTS

1. *General Instructions.*—Local officials within areas designated by proper military authority should make the following arrangements in preparing gas lamps for blackouts:

a. In areas where blackout street lighting is unnecessary, provide facilities and assign personnel to turn out gas lamps quickly—in not more than 5 minutes—after the blackout signal has been given. Example of manually operated extinguishing device on existing clock control mechanism is shown in figure 6.

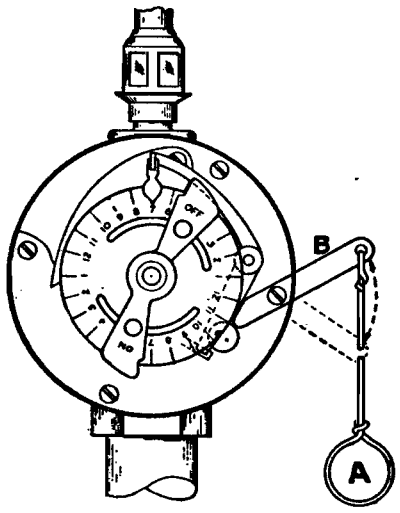

FIGURE 6.

Example of extinguishing device. Addition of pull wire (A) and tripping arm (B) permits existing control clock to be operated by assigned personnel extinguishing and relighting at will.

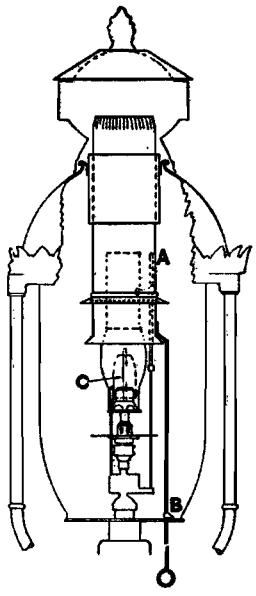

FIGURE 7.

Example of gas street light during blackout, with blackout screen (A) lowered into position by rod (B).

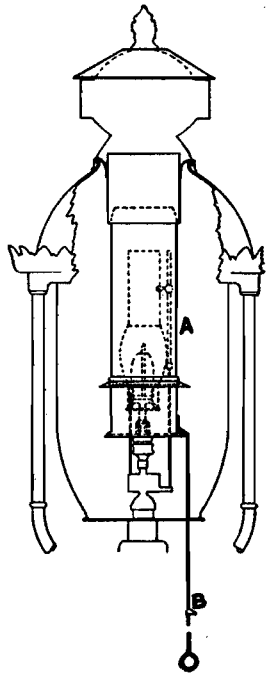

FIGURE 8.

Example of gas street light during normal operation, with blackout screen (A) raised by rod (B) so as not to interfere with light from mantle (C).

b. In areas where blackout street lighting is justified, install approved equipment for the conversion of existing gas lamps to blackout luminaires and assign personnel to operate such equipment promptly—in not more than 5 minutes after the blackout signal has been given.

2. *Conversion to Blackout Luminaire.*—Existing gas lamps can be converted to blackout luminaires by the addition of suitable blackout screens and operating devices. Screens shall be installed on the lamp in such a manner that there will be no interference with distribution of light below 70° during normal operation. Sketches of a gas blackout luminaire with screen in normal and blackout positions are shown in figures 7 and 8.

3. *Allowable Illumination.*—Intensity of illumination at street level during blackouts shall be that specified in subparagraph 6*a* of the main body of the specification. Color of light shall be that normally emitted by the gas lamp.

4. *Light Distribution.*—The candlepower distribution curve with screen in blackout position shall conform to the requirements of paragraph 7 of the main body of this specification.

5. *Mounting Height and Spacing.*—Same as paragraph 10 of the body of this specification.

6. *Construction.*—The construction of gas blackout luminaires and operating devices complying with this specification shall be such that:

a. Those parts which control the optical properties are not liable to variation or derangement in maintenance and use.

b. The materials and construction are rugged and are not subject to such deterioration in service as would be likely to bring photometric performance outside the limits laid down in paragraphs 6 and 7 of the main body of this specification.

c. Provision is made for ready mantle and globe replacement and maintenance.

d. Moving parts are not likely to jam.

7. *Marking.*—Screens shall be marked with appropriate mounting height as required in paragraph 15 of the main body of the specification.

8. *Design Approval.*—Approval of design of converted luminaire, including both optical performance and mechanical features, must be obtained from the War Department.

LABORATORIES ACCREDITED BY THE WAR DEPARTMENT:

Electrical Testing Laboratories, Inc., New York City, N. Y.

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